3RD SPACE EXPLORATION CONFERENCE & EXHIBIT

Expandable Habitat Structures for Long Duration Lunar Missions

Phil Spampinato
Manager Space Products, ILC Dover LP

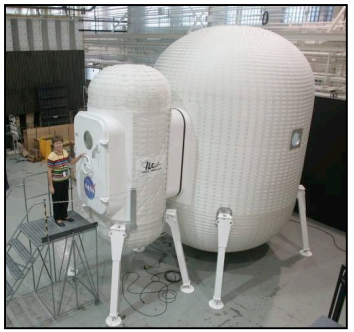
February 27, 2008

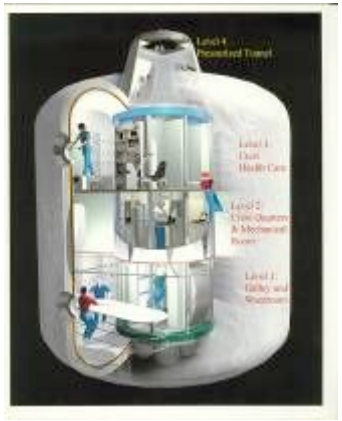
Habitat Classification

Habitat Construction Classes

- Pre Integrated (Hard Shell)

- **Pre-Fabricated (Expandable or Assembled)**



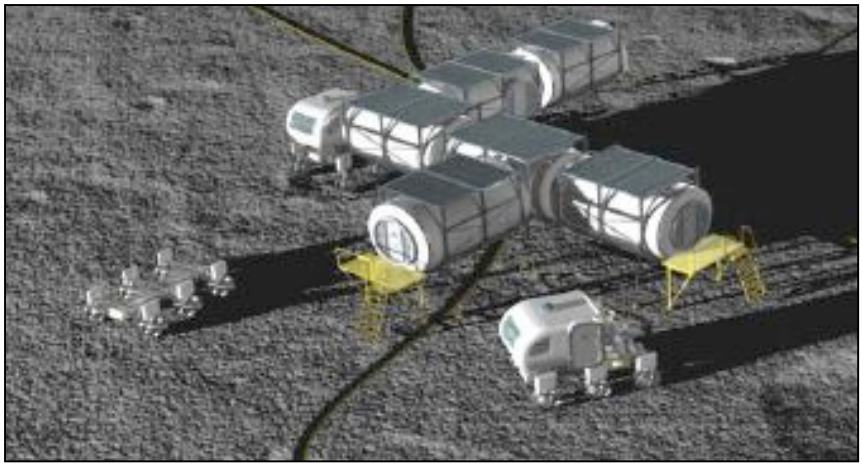


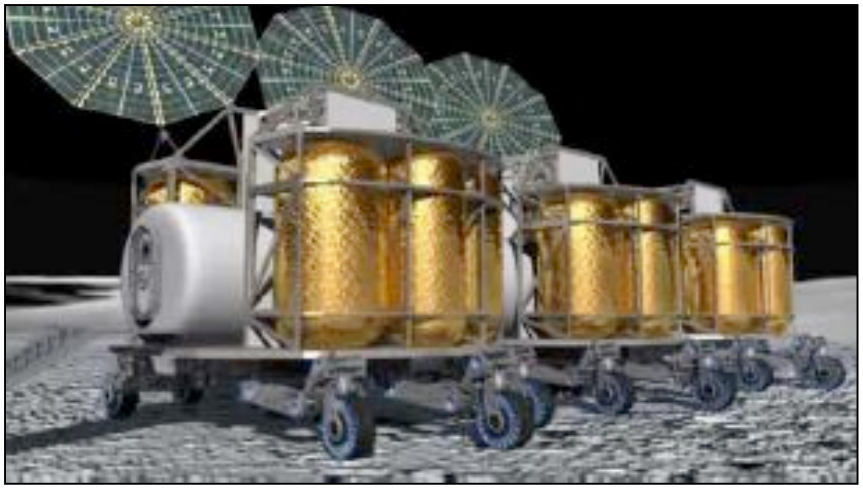
- In-Situ Resource Construction (Caves, Lunar Concrete, etc.)

Technical Challenges for Lunar Habitation

Structural Challenges

- Mass (structure, launch systems, etc.)
- Volumetric Efficiency (ratio of launch volume to deployed volume)
- Leak Detection / Health Monitoring
- Dust Mitigation
- Radiation Protection
- Equipment Interfaces
- Human Interface
- Thermal Regulation
- Handling / Moving
- Couplings between modules
- Uneven terrain

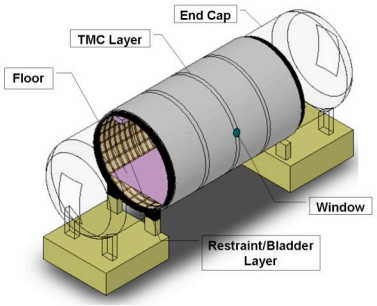




Recent Developments in Lunar Habitats

Recent Development Efforts

- Modeling & Analysis



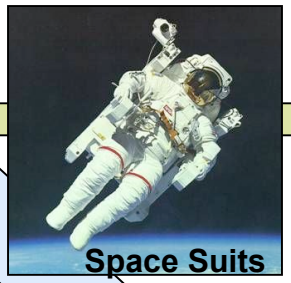
- Testing in Laboratory Environments

- Testing in Analog Environments

- Materials Development

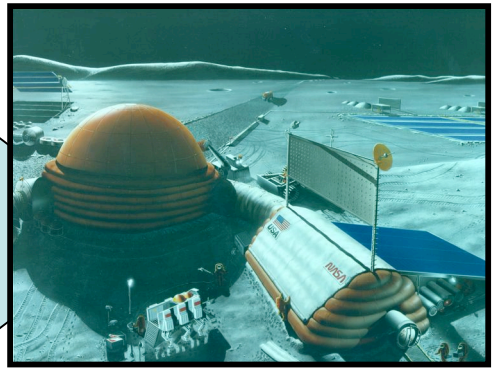
NASA ILC DOVER creating what's next

Leveraging Proven Expandable Technologies



Space Systems

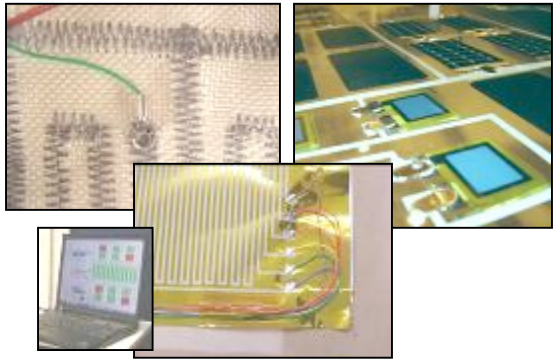
LAT Driven Habitat Dev't



Lunar Habitats

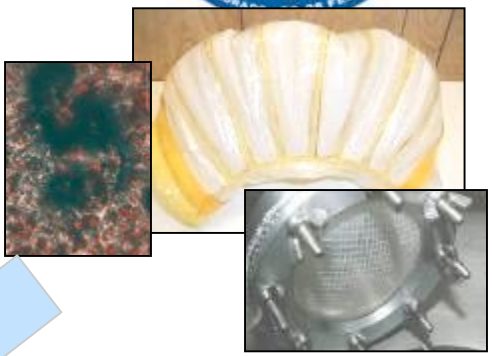
Terrestrial Systems

Intelligent Flexible Materials (InFlex)



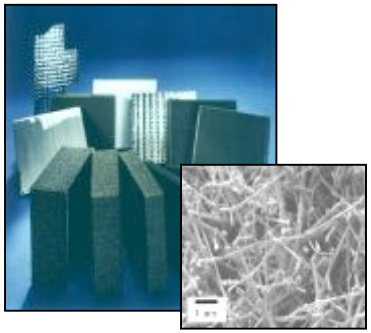
Structural Health Monitoring & Leak Detection

Signal Transfer Systems (wireless & wired)



Self Healing Bladder Materials

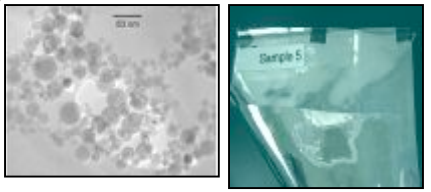
Exploration Applications



Enhanced Radiation Protective Materials

Anti-Microbial Materials

Localized Power Generation & Storage



Low Permeation Materials

Using Multi-functionality to reduce mass and improve safety

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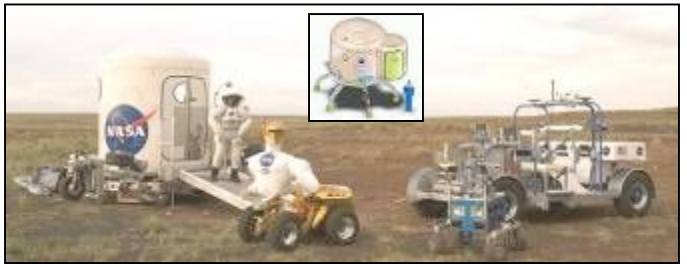
Expandable Lunar Habitat Demonstrator

Studies:

- Packing & Deployment
- Crew Interface
- InFlex Materials Integration (HMS, etc.)
- Hardware Interface (doors, windows, lights, etc.)
- Manufacturing
- Acoustical
- Outfitting
- Analog Test (DRATS)



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NASA

Antarctic Habitat Demonstrator

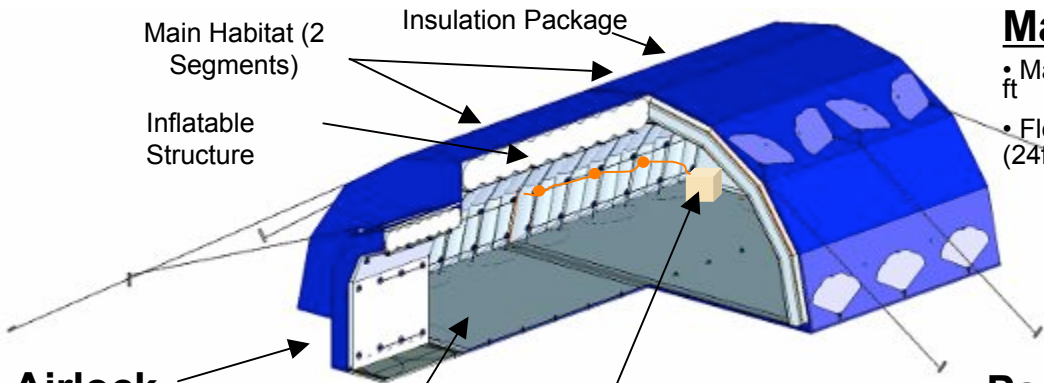
The Habitat is here (McMurdo Station, Antarctica, Science Support Center) through 2008. It is being continuously monitored via web-based tools and NSF personnel. It will be moved in the 2009 season to support NSF operations.

Antarctic Habitat Demonstrator

- NASA / NSF / ILC Dover Innovative Partnership Program (IPP)
- Test of expandable structures in Antarctic Analog to advance NASA knowledge base for lunar application
- Test of expandable structures to advance NSF knowledge and assess applicability to polar missions

System Requirements (NASA & NSF Combined) - Annotated

- Reconfigurable components
- Erected by 4 people in 4 hours
- Can withstand 100 mph winds
- High Packing Efficiency
- Can deploy on uneven ground
- Withstand the Antarctic winter
- Multiple cycle use
- Lighting/power/data acquisition
- Meet NSF building codes



Main Habitat

- Max Head Room: 8 ft
- Floor Area: 384 sq ft (24ft x 16ft)

Packed System

- 1000lb (2x 3'x4'x8')
- 15:1 Packing Efficiency

Antarctic Habitat Demonstrator Study Goals

Large Expandable Structures:

- ☑ – Packing efficiency & shipping/handling survival
- ☑ – Deployment operability in a gravitational environment and in polar gear (representing space suits)
- ☑ – Adaptability to uneven and rugged surfaces representing the lunar surface
- ☑ – Reconfigurability
- Ongoing – Performance in a harsh environment
- Partial – Deployment with integrated electronics (power, lighting, sensors, etc.)
- ☑ – Remote structural health monitoring over long periods of time
- ☑ – Use of in-situ materials for shielding from radiation
- ☑ – Lunar dust mitigation practices

Packing, Shipping & Deployment Studies




Achieved a packing efficiency of 15:1 (packed to deployed volume)





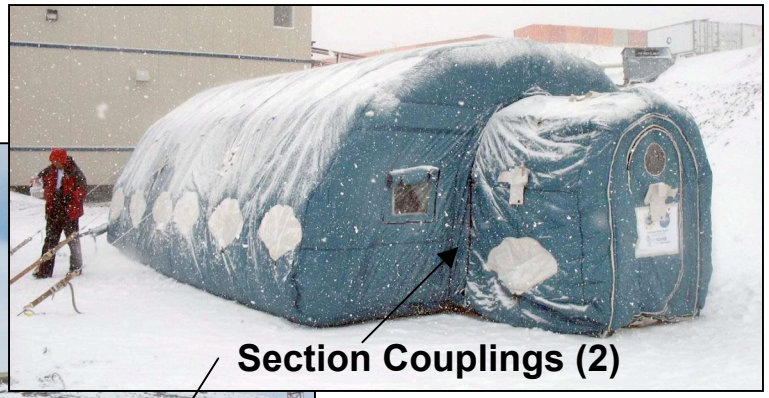
Survived truck (DE to CA), Ship (CA to NZ), C17 (NZ to McMurdo)




Deployed by 3 people in ECWG in under 50 minutes (11 min inflation)

Reconfigurability Studies

Connections between sections were simple in ECWG + demonstrated reconfigurability

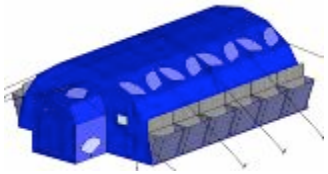


The system adapted well to the uneven ground due to compliant interfaces and structures

Packed & deployed system dozens of times

Radiation Protection Studies

Researching ways to apply regolith to the walls of a structure for radiation shielding

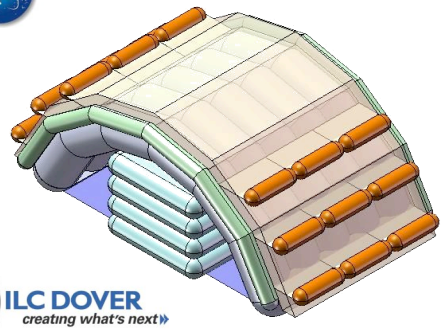


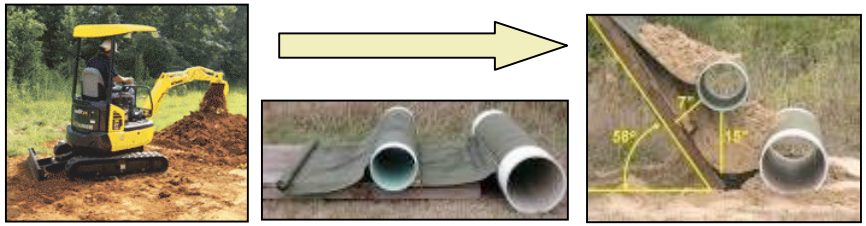
Fill bags attached to structure

Bags

Blankets

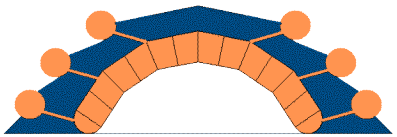
Flexible PE blankets applied where required



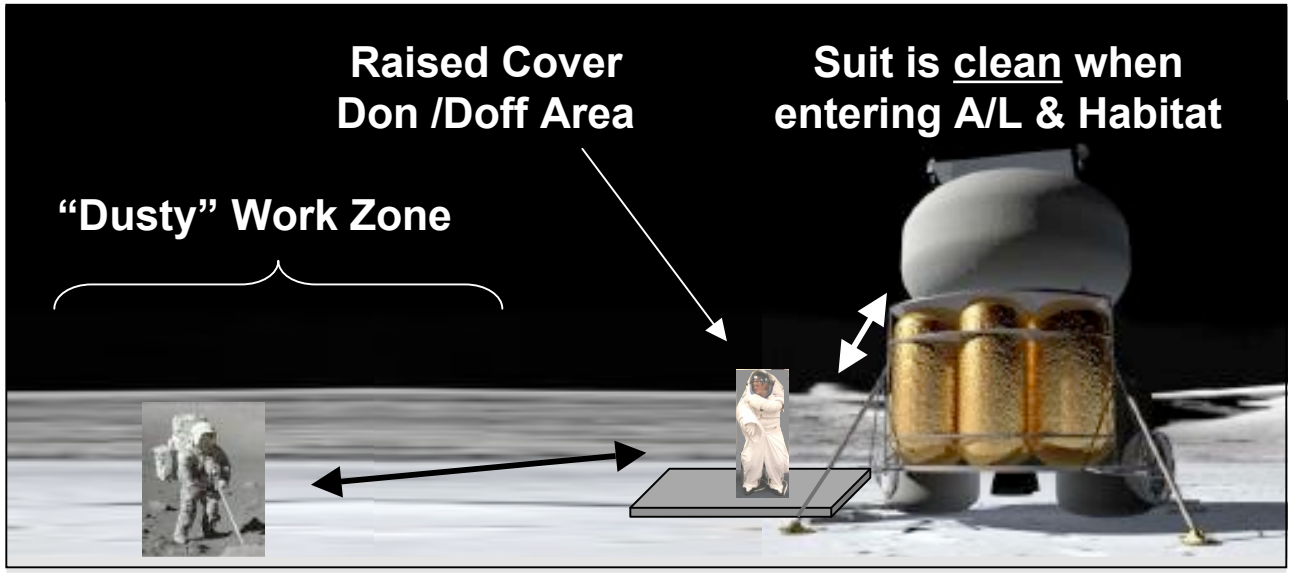


Push regolith on deflated structure, inflate structure, capture regolith on walls

Regolith Lifter



Dust Mitigation Studies



Conceptual solution for EVA suit dust covers

Protective covers are used daily in many applications (military CBRN, bio-suits, semiconductor, etc.)

Protective Covers

- Keep dust off the suit
- Keep dust from entering the A/L & Hab
- Reusable
- Applicable to robotics
- Enhance safety & improve logistics
- Applicable to Mars

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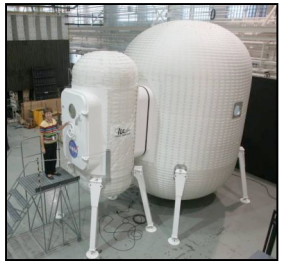
Summary

- Expandable habitat developments are leveraging proven technologies

- Laboratory and Analog testing is providing useful data to guide system development



- Advanced flexible materials and embedded sensor technologies are maturing

- Technology development timelines coincide with LAT needs